NUCLEAR ENERGY RESEARCH INITIATIVE

Fundamental Processes of Coupled Radiation Damage and Mechanical Behavior in Nuclear Fuel Materials for High Temperature Reactors

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Collaborators: Idaho National Laboratory; Los Alamos National Laboratory

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Project Description

A longstanding issue for the nuclear industry is the degradation of the mechanical properties of nuclear fuels under irradiation, including both the fissionable material and cladding. Developing fuel systems with improved resistance to radiation damage will allow longer burnups, improved usage efficiency, increased time between refueling, and decreased waste. The objective of this project is to elucidate the relationship among the microstructure, radiation damage, and mechanical properties of nuclear fuel materials. This research will focus on developing an understanding of 1) the fundamental mechanisms of radiation damage in polycrystalline materials, 2) the effect this damage has on plastic deformation, and 3) the effect of mechanical deformation on radiation tolerance.

The researchers will use hexagonal close-packed (HCP) Ti (representing HCP Ti alloys for fast reactors and zircaloy for cladding in thermal reactors) and UO_2. To simulate radiation damage, they will apply state-of-the-art, large-scale atomic-level simulation through a judicious combination of conventional molecular-dynamics (MD) and accelerated MD methods. They will elucidate mechanical behavior by applying large-scale MD simulations. This systematic program for simulating the effects of irradiation on the structural and mechanical properties of polycrystalline Ti and UO_2 will identify radiation damage mechanisms and provide insights into the expected behavior of nanocrystalline microstructures and nanocomposites. This work will ultimately help researchers design microstructures that are less susceptible to radiation damage and thermomechanical degradation.

Workscope

This research will consist of the following four tasks:

- Determine effects of radiation damage in fine grained polycrystalline Ti and UO_2
- Characterize the mechanical properties of unirradiated polycrystalline Ti and UO_2
- Elucidate the effect of radiation damage on mechanical properties of polycrystalline Ti and UO_2
- Determine the effect of plastic deformation on radiation resistance in polycrystalline Ti and UO_2